Space Weather Technical Forecast

Issued on Monday 23 December 2024 at 00:30 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: R1/R2 Likely. Possible glancing CME early on 24 Dec.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate with three M-class flares observed, with a peak M1.1 at 22/2050UTC from AR3932 in the southeast.

There are currently nine sunspot regions on the visible, one of which is unnumbered near the southeast limb. The southeast quadrant remains the focus of main solar activity, containing a cluster of the four largest regions, three of which (AR3928, AR3932 and AR3933) are moderately wide bipolar spot groups, showing some degree of magnetic complexity. AR3926 in the southwest has recently seen a small opposite polarity spot develop, and is now a simple bipolar group. AR3934 in the northeast is also appearing to be a fairly large spot group as it comes more into view. Other remaining regions are relatively small, stable and magnetically simple.

A filament lift-off from the northeast and associated CME from late in the UTC day on 20 Dec was modelled and gives a potential peripheral glance around 24/0000 UTC.

A number of other CMEs have been observed in available imagery during the period. Analysis of these suggests none have an Earth-directed component, however confidence in the complex number of CMEs is currently low.

Solar Wind / Geomagnetic Activity: Solar winds, observed at L1 by DSCOVR and ACE have shown Elevated to Strong conditions with uncertain cause - perhaps coronal hole influence from CH01/-. The solar wind speeds have averaged around 600km/s, but reached a peak of 794km/s at 22/1817UTC. Density was average to below average. The Interplanetary Magnetic Field (IMF), Bt, was Moderate at times, between 6-9nT. The north-south component, Bz, varied weakly throughout, ranging between +7 and -7nT. Geomagnetic activity was Quiet to Unsettled (Kp2-3).

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV) observed at GEO reached a peak of 5 pfu at 22/0630 UTC.

High energy electron flux (greater than 2MeV) observed by GOES16 peaked at Moderate levels, with 682pfu observed at 22/1735UTC. The associated 24-hour fluence was below the Active (1e8 integrated flux) threshold. The 23/0001UTC observation was 2.44e7 integrated pfu, with a slight rising trend.

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Met Office Space Weather Technical Forecast

Four-Day Space Weather Forecast Summary

Solar Activity: Isolated M-class flares are Likely, mainly from AR3928 or AR3932, perhaps bolstered slightly beyond the current UTC weekend by returning regions. A Slight Chance of isolated X-class flares is maintained throughout.

Solar Wind / Geomagnetic Activity: A filament lift-off from the northeast from late in the UTC day on 20 Dec was modelled and gives a potential peripheral glance around the turn of Day 2 (24 Dec). No other Earth-directed CMEs appear in the forecast, however the number of CMEs over the past few days means confidence is low.

Overall, conditions are likely to remain Quiet to Unsettled. Given current Elevated solar wind speeds, there is a chance of Active conditions through the period, tentatively peaking around days 1 and 2 (23-24 Dec) due to CH01/- and possible glancing influence from 20 Dec CME, with a slight chance of G1 Minor Geomagnetic Storms.

Energetic Particles / Solar Radiation: There is a Chance of S1-level or greater enhancements early in the period, due to current slightly enhanced near-Earth proton counts. This risk should relax back in the absence of any significant flares, with most of the risk from the front-side then tied to the westward advance of the sunspot cluster located currently in the southeast.

The high energy electron forecast carries lower-than-average confidence due to inherited uncertainties from the geomagnetic forecast, especially surrounding any potential glancing CME influence around Day 2 (24 Dec). Overall, the chances of disturbances in the period are higher than average, with perhaps a gradually rising Slight Chance perhaps the best representation.

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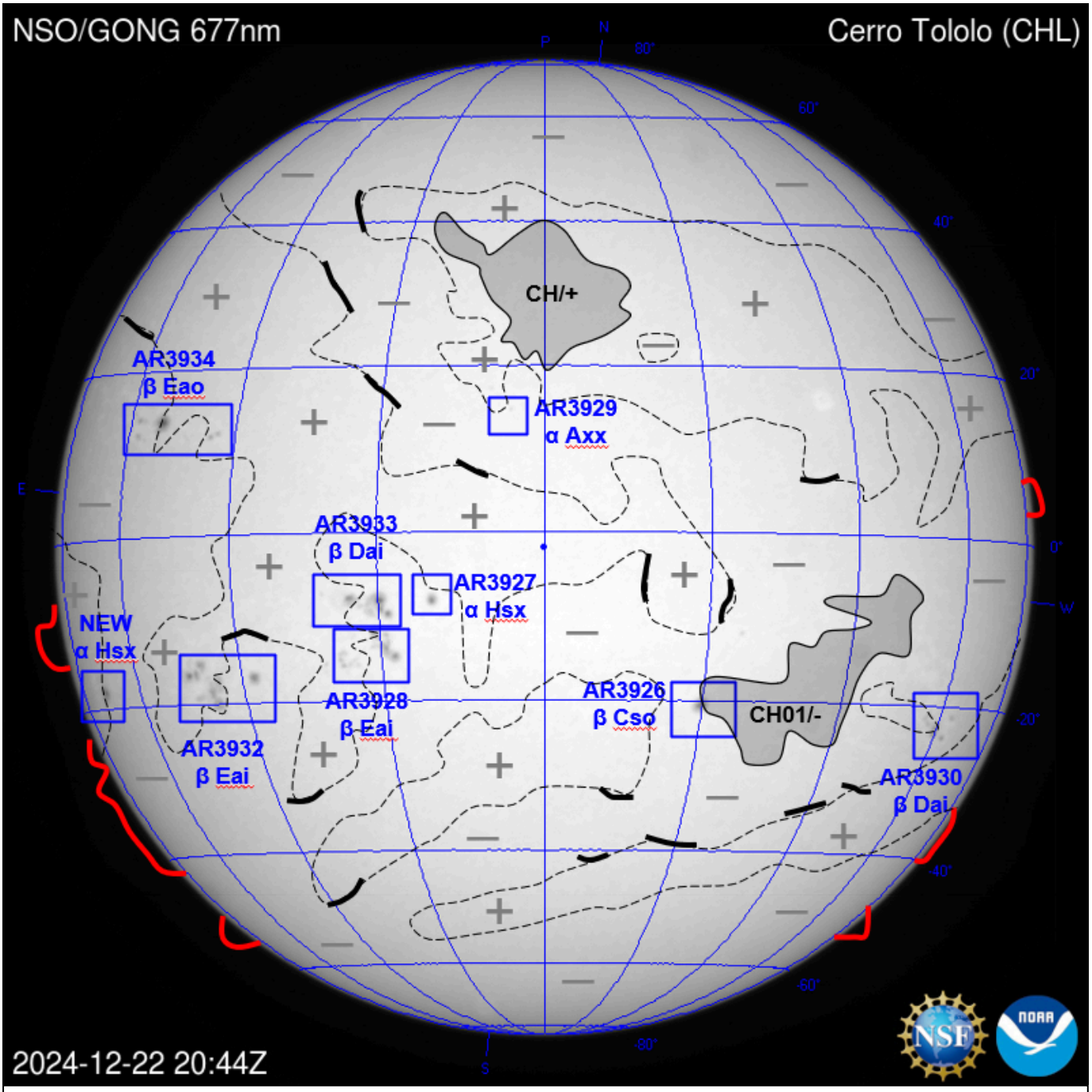
Figure 1: Solar Synoptic Map - valid 22/2044 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms

A filament lift-off from the northeast from late in the UTC day on 20 Dec was modelled and gives a potential peripheral glance around the turn of Day 2 (24 Dec). There are also a number of other CMEs (coronal mass ejections) observed during the period, which have now been analysed, including two CMEs off the southwest limb early on 22 Dec, but current results suggest they are all directed off the Sun-Earth line.

Current solar winds are Elevated via an uncertain mechanism, potentially early connection to CH01/- given the negative phi angle. The coronal hole itself has shown changes in shape over the past three or four days, with some north-westward elongation perhaps taking place, making onset forecasting more complicated. Flux looping to its immediate west in GOES SUVI 195 imagery isn't helping by potentially masking any leading portion of this hole, although the main bulk of the feature still seems far east for current observations, and there may be an alternative cause. This is the main forecast feature due in the period, and the fact that it may already be in course lowers confidence for the forecast as a whole. CH01/- itself is a non-persistent feature, further exacerbating the issue.

Overall, conditions are likely to remain Quiet to Unsettled. Given current Elevated solar wind speeds, there is a chance of Active conditions through the period, tentatively peaking around days 1 and 2 (23-24 Dec) due to CH01/- and possible glancing influence from 20 Dec CME, with a slight chance of G1 Minor Geomagnetic Storms. A mitigating factor against larger effects from any coronal hole is being near the semi-annual minimum coronal hole geo-effectivity near the solstice.

Geomagnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	10	20	5	5
Strong	G3	No	1	5	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

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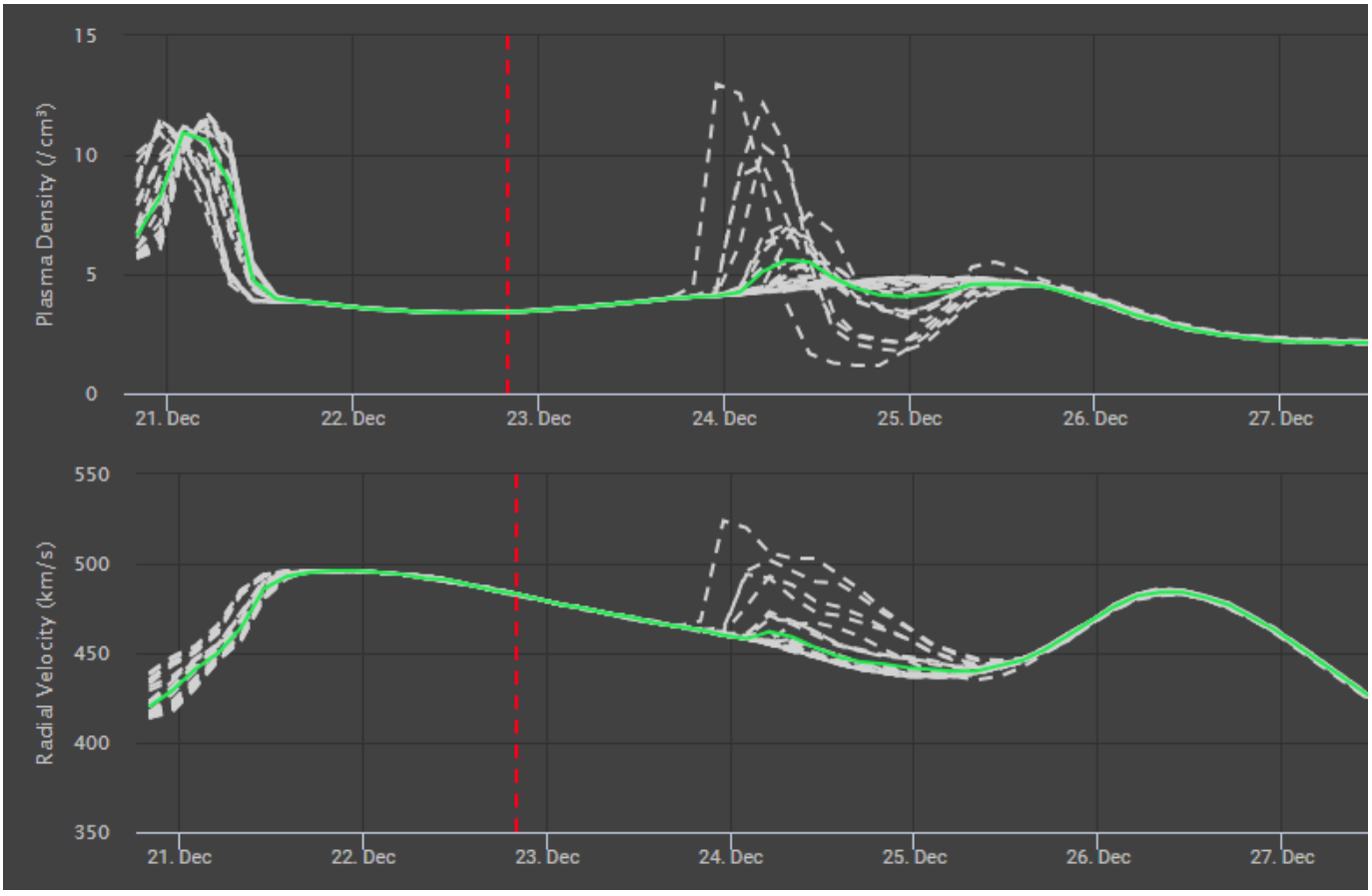
Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R⊙ (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed (km/s)	Estimated Arrival Time (UTC)	Comments
21/0535 UTC	Partial	Filament	NE quadrant	532	24/0000 UTC	Possible glance but low confidence.

Figure 2: MOSWOC Ensemble model, showing potential for CME glance early on 24 Dec.



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Radio Blackouts - X-Ray Flares

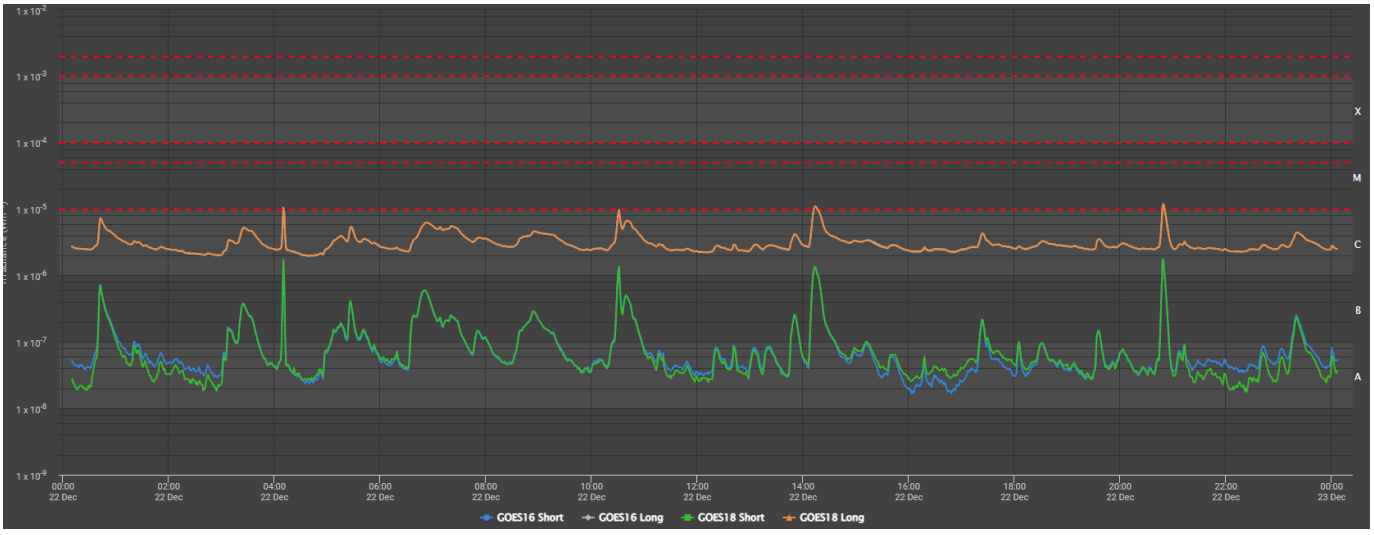
Solar activity has been Moderate with three M-class flares observed, with a peak M1.1 at 22/2050UTC from AR3932 in the southeast. Further isolated M-class flares are considered likely, with a slight chance of X-class flares. The most likely source being from the cluster of sunspot regions in the southeast quadrant.

There are currently nine sunspot regions on the visible, one of which is unnumbered near the southeast limb. The southeast quadrant remains the focus of main solar activity, containing a cluster of the four largest regions, three of which (AR3928, AR3932 and AR3933) are moderately wide bipolar spot groups, showing some degree of magnetic complexity. AR3926 in the southwest has recently seen a small opposite polarity spot develop, and is now a simple bipolar group. AR3934 in the northeast is also appearing to be a fairly large spot group as it comes more into view. Other remaining regions are relatively small, stable and magnetically simple.

There is the potential for some further eastern limb returning regions over the next day or so, perhaps foremost amongst these being Ex-AR3910, with Ex-AR3912 then also due to rotate around on Day 1 (23 Dec). The potential of this is the reason the flare risk increases slightly through the period.

X-Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 (M Class)	Yes	60	65	65	65
Very Active	R3-R5 (X Class)	No	10	10	10	10

Figure 3: GOES16-18 X-Ray flux trace.



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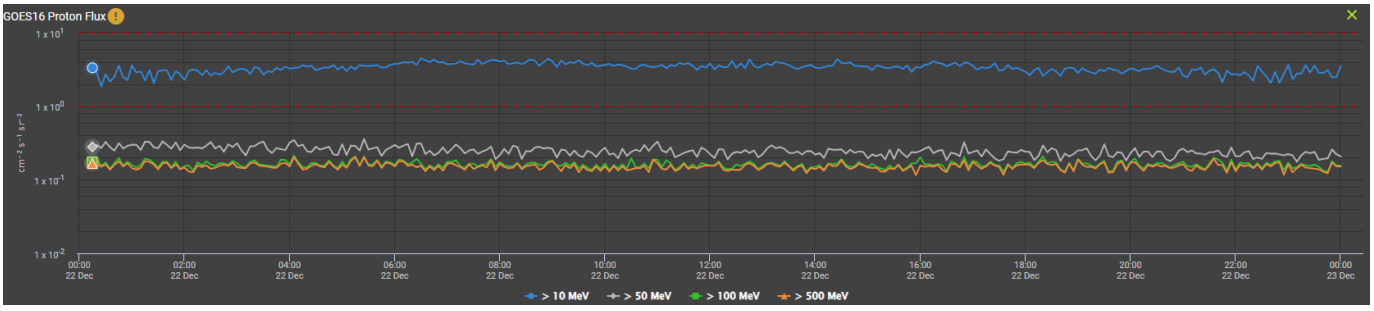
Solar Radiation Storms (High Energy Protons)

The source of the currently observed enhancement in the near-Earth environment is uncertain, but given the damped rise and soft spectrum, an eastern solar hemisphere or far-sided source seems most likely, perhaps from 19 December with possible further additions since. The chances of S1-scale or greater events are currently slightly raised as a result of the increased counts, however barring further additions, a relaxing back towards the raw disc value of 15% is forecast for a time. An increasing trend is then anticipated as the main sunspot regions currently located in the southeast, advance westwards.

Radiation Storms Probability (Exceedance)	Level ($cm^{-2}sr^{-1}s^{-1}$)	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	20	15	20	20
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES-18 Proton Flux.



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High Energy Electrons (≥ 2MeV)

The current high energy electron flux is oscillating between background and moderate levels. This trend may accelerate at GEO given recently observed Elevated solar winds and periods of Unsettled geomagnetic activity, with the period as a whole carrying low confidence as a result of an uncertain CME picture and non-recurrent - and in fact possibly already underway - coronal hole influence.

MOSWOC REFM gives a reasonable guide, although does not represent either any impinging CME activity nor non-persistent coronal holes, and as such the forecast carries low confidence as already mentioned.

All considered, there is a gradually rising Slight Chance of 24-hour fluence reaching Active.

GEO Electron Environment	Level ($cm^{-2}sr^{-1}$ day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability (Exceedance)			(%)	(%)	(%)	(%)
Active	≥ 2 MeV ≥ 1×10^{8}	No	5	10	15	15
Very Active	≥ 2 MeV ≥ 1×10^{9}	No	1	1	1	1

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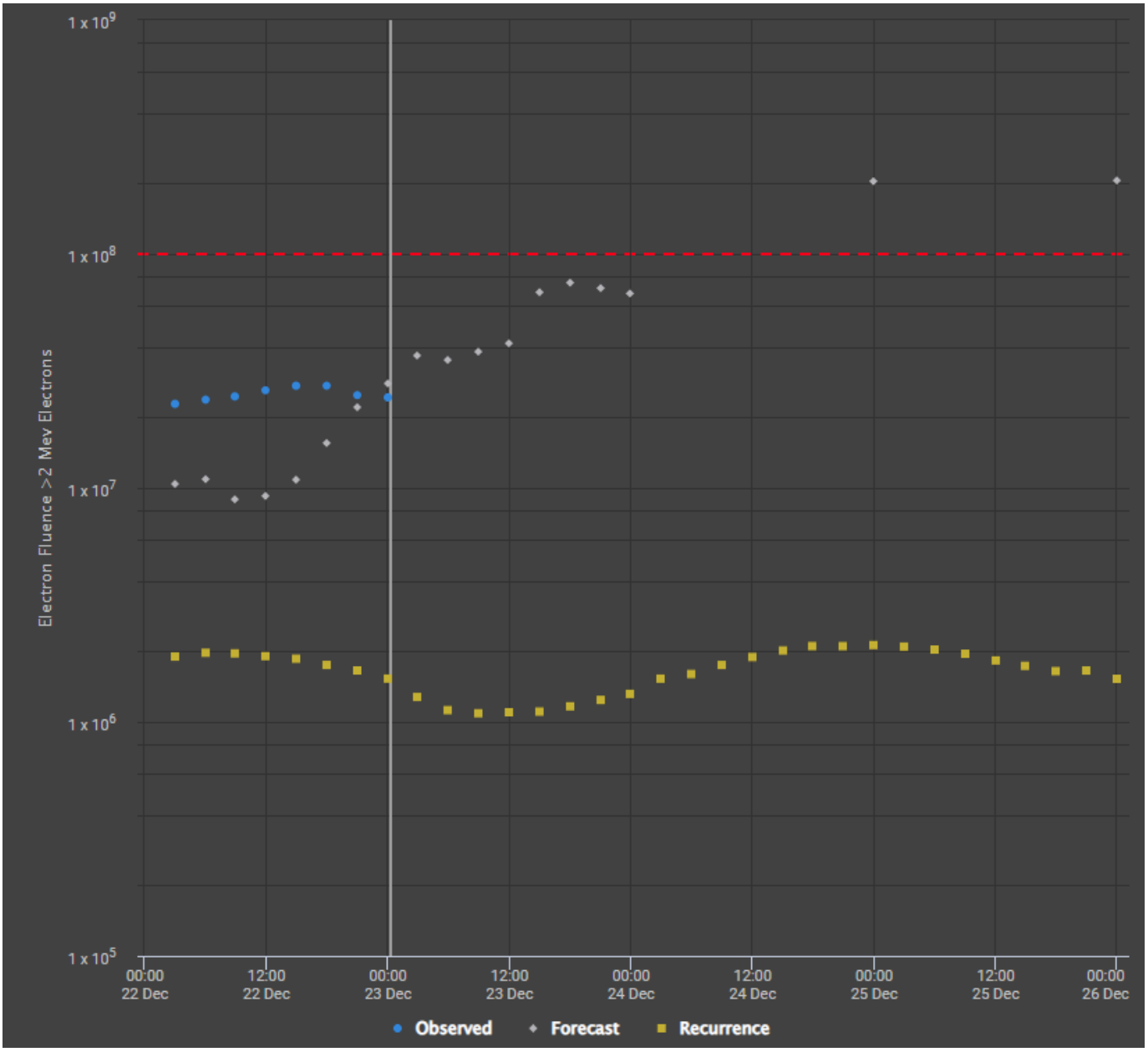
Figure 5: MOSWOC REFM electron fluence.



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